A Low-Cost, Real-Time Optical Sensor for Environmental Monitoring and Homeland Security

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The Georgia Tech Research Institute (GTRI) has developed and tested an optical sensor capable of detecting a wide variety of chemical and biological species in air, water, and biological samples. The sensor is fast, highly sensitive, and provides a real-time direct measurement with no additional steps or consumable reagents. . Many of the sensor's components are inexpensive and off the shelf, including a laser diode light source and charge-coupled device (CCD) detector; the estimated manufacturing cost of the sensor is less than $1000. At the heart of the device is a planar optical waveguide interferometer that has an evanescent field sensitive to index of refraction changes in the volume immediately above (up to .5 microns) the surface. Placing a chemically sensitive film within this region provides the basis for the sensor response. To measure this response, a sensing beam is optically combined with an adjacent reference beam, creating an interference pattern of alternating dark and light fringes that is imaged on a detector. When a chemical or biological interaction occurs in the sensing arm, the interference pattern shifts, producing a sinusoidal output that is converted to total phase change using a Fourier transform algorithm. The magnitude of this change is proportional to the concentration of the analyte present. Currently, the integrated optic waveguide platform consists of up to eight sensing channels on a 1 × 2-cm glass substrate. A different sensing film can be deposited on each channel allowing for multiple target sensing.

Chemistries have been developed for a wide variety of chemical and biological species including aromatic and chlorinated solvents, ammonia, chemical warfare simulants, illicit drugs, proteins (such as ricin) and bacteria (*Salmonella*, *Campylobacter*, and anthrax). Limits of detection range from the low ppb for small molecules to 1,000 cells/mL for whole organisms. Environmental applications include on-site screening of soil and groundwater samples, long-term monitoring of groundwater contamination (field testing for detection of chlorinated hydrocarbons has been conducted), and detection of foodborne pathogens. Homeland security applications for the sensor include low-cost systems for perimeter monitoring, detection tools for first responders, and use of the sensor in unmanned aerial vehicles.